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# Comparison of DDSI Experimental and Simulated Results

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LA-UR-XXXXXX

# Summer Fun (Rio Grande Bridge on the way to Taos)



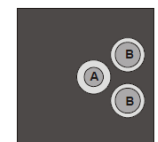
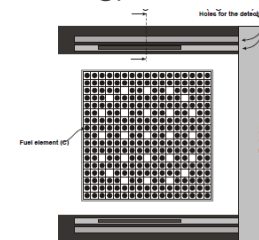
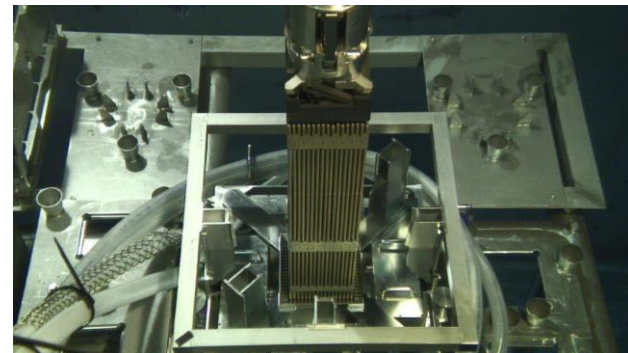
# Amanda Youmans (NEN-1)

- Educational Background
  - BS Nuclear Engineering RPI, 2014
  - Current Nuclear Engineering PhD student at RPI
- PADGS
  - Nuclear Safeguards and Technology
  - Mentor: Alexis Trahan
- Research
  - Modeling DDSI and SKB50 spent fuel assemblies with MCNP6



# Research Overview and Motivation

- **Safeguarding spent nuclear fuel**
  - Spent fuel contains reactor grade plutonium
  - Spent fuel is often stored on-site at nuclear power facilities
  - The IAEA is tasked with verifying that no SNM is misdirected
- **Existing technologies are inadequate for reliably determining if fuel pins have been diverted**
  - Fork detector (total gamma and neutron signals)
    - No coincidence, no measure of the fissile mass
    - Only observe gammas from the outside of the assembly (self-shielding)
  - Cherenkov cameras
    - Murky water, only see the top of the assemblies
    - Can only measure higher activity assemblies



A = ionisation chamber  
B = fission chamber  
C = fuel element

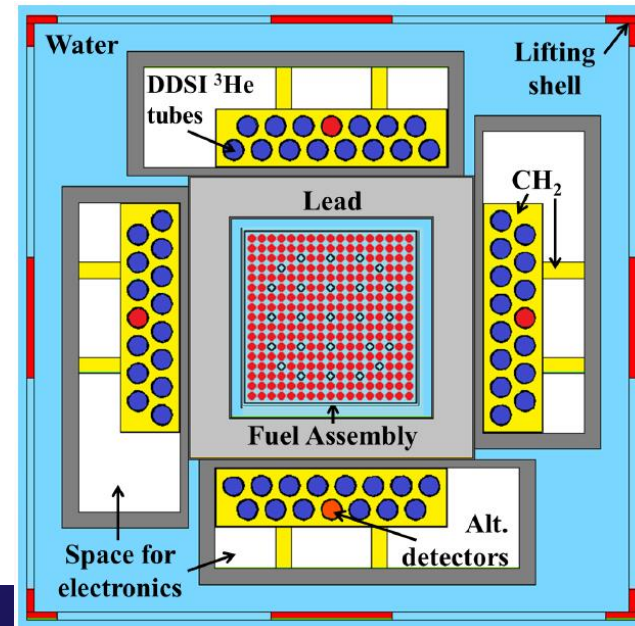


Figure 1. Horizontal cross-section of the FORK detector with a 17x17 PWR fuel assembly

Figure 2. Vertical cross-section of an arm of the FORK detector, showing the position of the three detectors

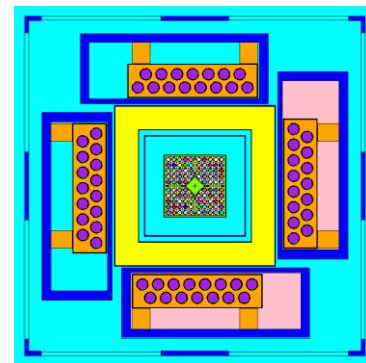
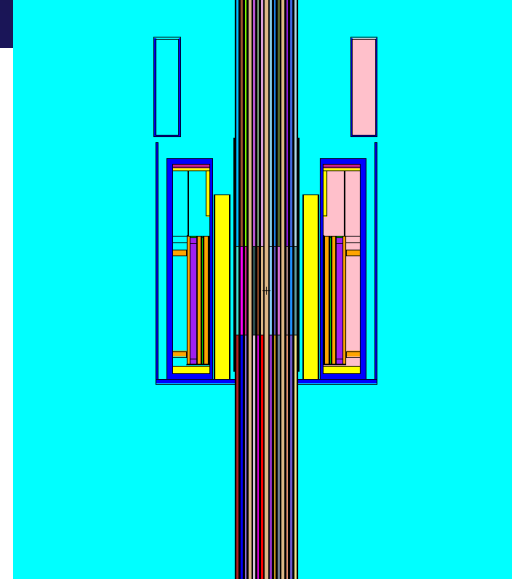
# Research Approach: Modeling the Differential Die-away Self Interrogation (DDSI) Detector System

- **DDSI was developed at LANL and tested at Clab in Sweden on the SKB50 set of PWR and BWR spent fuel assemblies**
  - Passive Non-Destructive Assay tool
  - Well-known spent fuel assemblies used to benchmark the system
- **MCNP modeling of DDSI**
  - Used to better understand the system
    - Lower systematic uncertainties
    - Develop data analysis methods, eg. Correction factors
  - Sensitivity studies
    - Assembly position



# Summary of Results

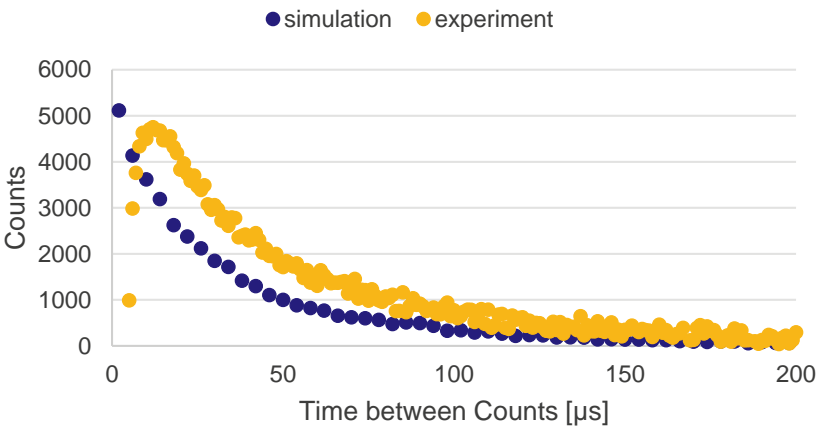
- **Modeling of 25 PWR spent fuel assemblies in DDSI**
  - Singles, doubles rates
  - RAD
  - Die-away times
- **Modeling of 25 BWR spent fuel assemblies in DDSI**
  - Singles, doubles rates
  - RAD
  - Die-away times
- **Position sensitivity for PNAR analysis technique**
  - Ratios of singles rates in each detector between simulations with the detectors at different positions





# Modeling of PWR spent fuel assemblies in DDSI

RAD for PWR1



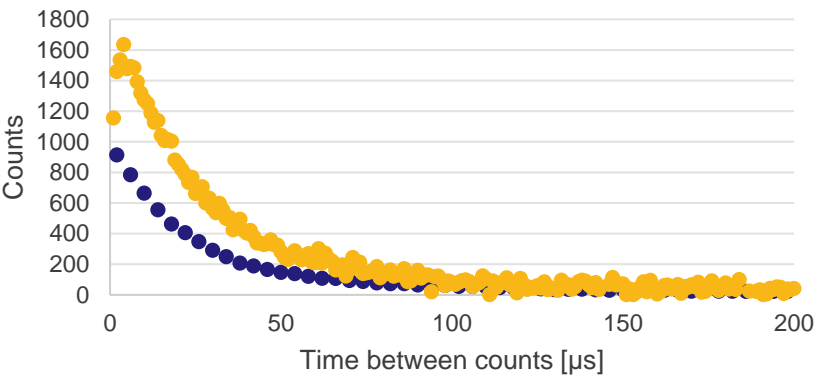
	Fast Tau			Slow Tau		
PWR#	Sim [μs]	Exp [μs]	C/E	Sim [μs]	Exp [μs]	C/E
1	12.9	25.6	<b>0.505</b>	53.7	60.2	<b>0.892</b>
2	17.9	23.0	<b>0.778</b>	57.2	60.6	<b>0.943</b>
25 PWR avg.	-----	-----	<b>0.833 ± 0.129</b>	-----	-----	<b>0.857 ± 0.061</b>

	Singles Rate [cps]			Doubles Rate [cps]		
PWR #	simulation	experiment	C/E	simulation	experiment	C/E
1	5551482	3907930	<b>1.421</b>	242344	94186	<b>2.573</b>
2	4032254	3411292	<b>1.182</b>	179966	87284	<b>2.062</b>
3	3042818	2461852	<b>1.236</b>	131338	69334	<b>1.894</b>
25 PWR avg.	-----	-----	<b>1.176 ± 0.114</b>	-----	-----	<b>1.613 ± 0.319</b>

# Modeling of BWR spent fuel assemblies in DDSI

RAD for BWR1

● simulation ● experiment

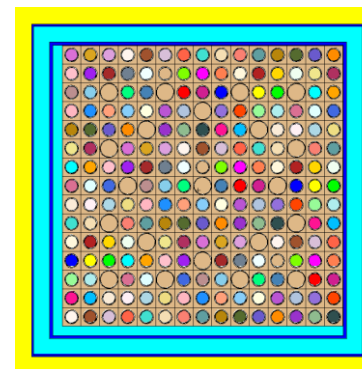
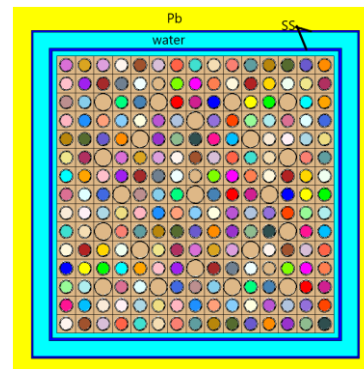
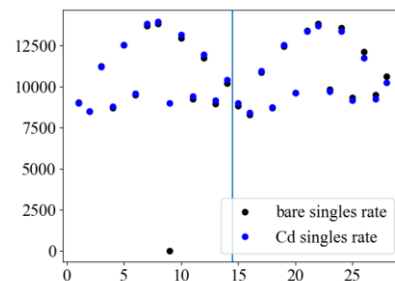
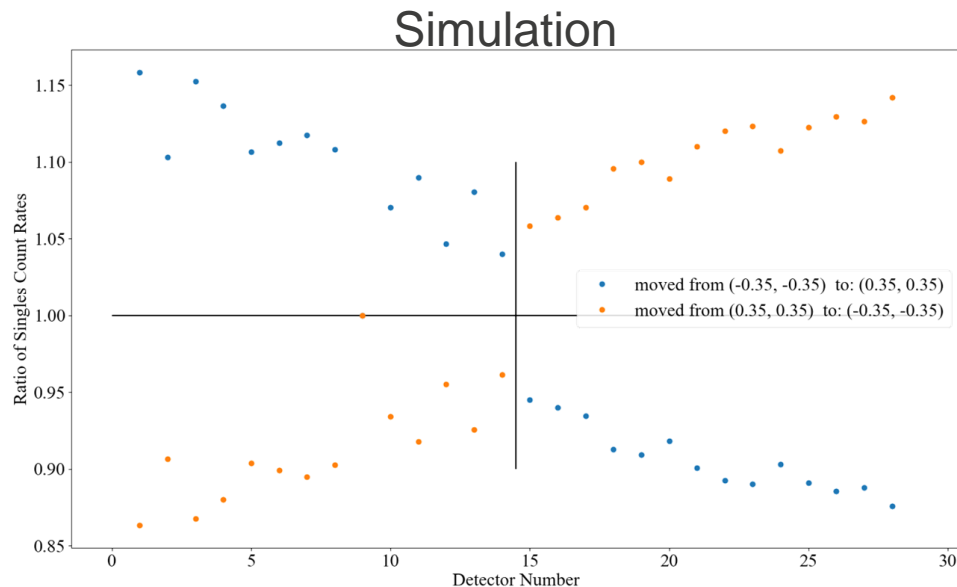


	Fast Tau			Slow Tau		
BWR#	Sim [μs]	Exp [μs]	C/E	Sim [μs]	Exp [μs]	C/E
1	14.260	18.142	<b>0.786</b>	83.182	61.525	<b>1.351</b>
2	18.218	17.045	<b>1.068</b>	86.160	54.515	<b>1.580</b>
25 BWR avg.	-----	-----	<b>0.979 ± 0.050</b>	-----	-----	<b>1.377 ± 0.110</b>

	Singles Rate [cps]			Doubles Rate [cps]		
BWR #	simulation	experiment	C/E	simulation	experiment	C/E
1	788270.5	1159563	<b>0.679</b>	11477.22	27324.75	<b>0.420</b>
2	715181.9	962173.6	<b>0.743</b>	11043.25	23054.76	<b>0.479</b>
3	499429.6	833822.9	<b>0.598</b>	7663.003	20715.96	<b>0.370</b>
25 BWR avg.	-----	-----	<b>0.721 ± 0.093</b>	-----	-----	<b>0.423 ± 0.078</b>

# Position sensitivity for PNAR analysis technique

- 1 mm movements were modeled for PWR11 spent fuel assembly
- Position has a significant effect on the rates in each detector
  - $\pm 15\%$  singles rate when moved the maximum of 7 mm in x and y directions



# Conclusion

- The End
- Any Questions?

